National Aeronautics and Space Administration

Earthquake Triggering and Stress Changes in the September 2017# Mexican Earthquake Sequence

and February 2018

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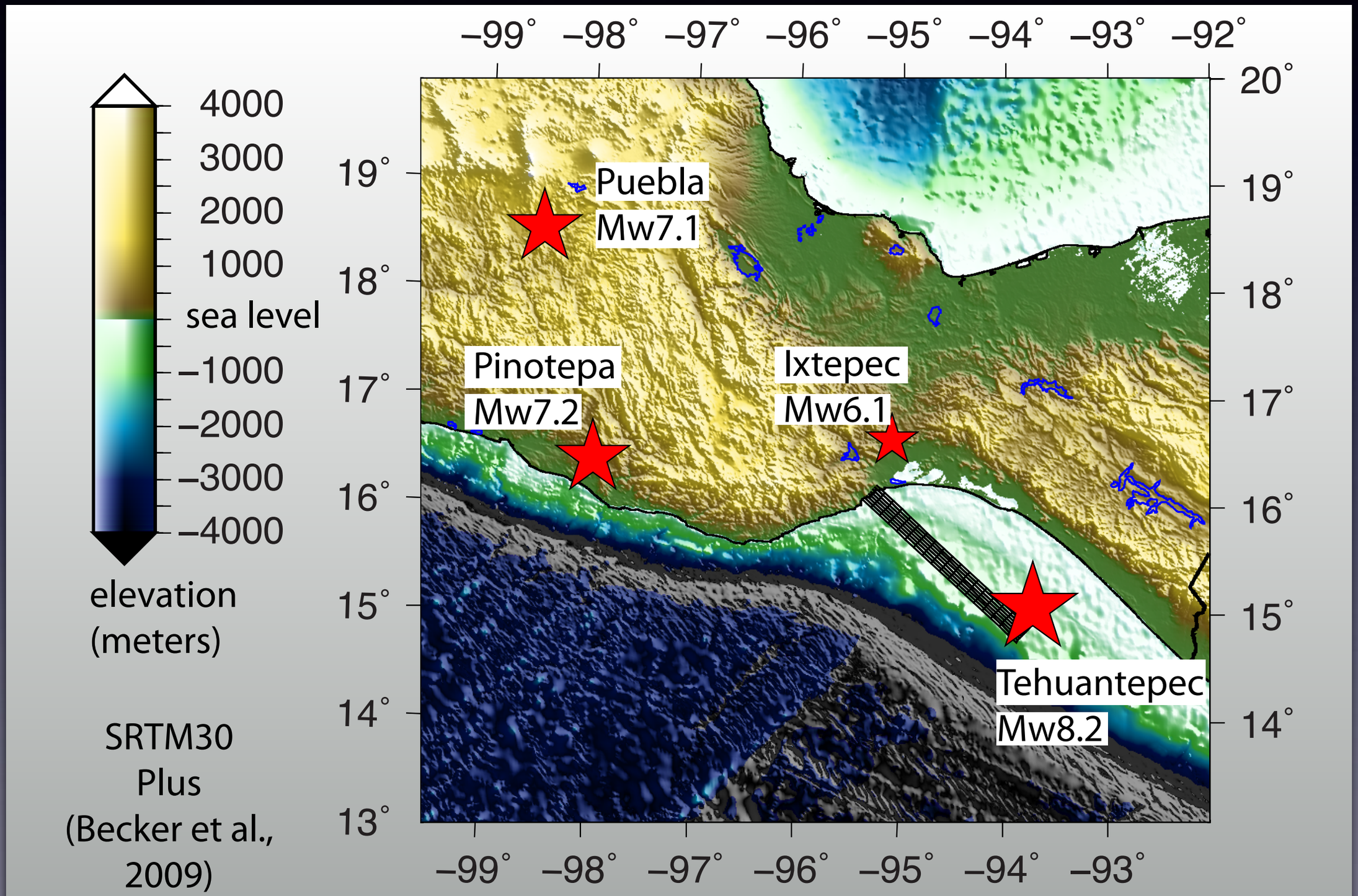
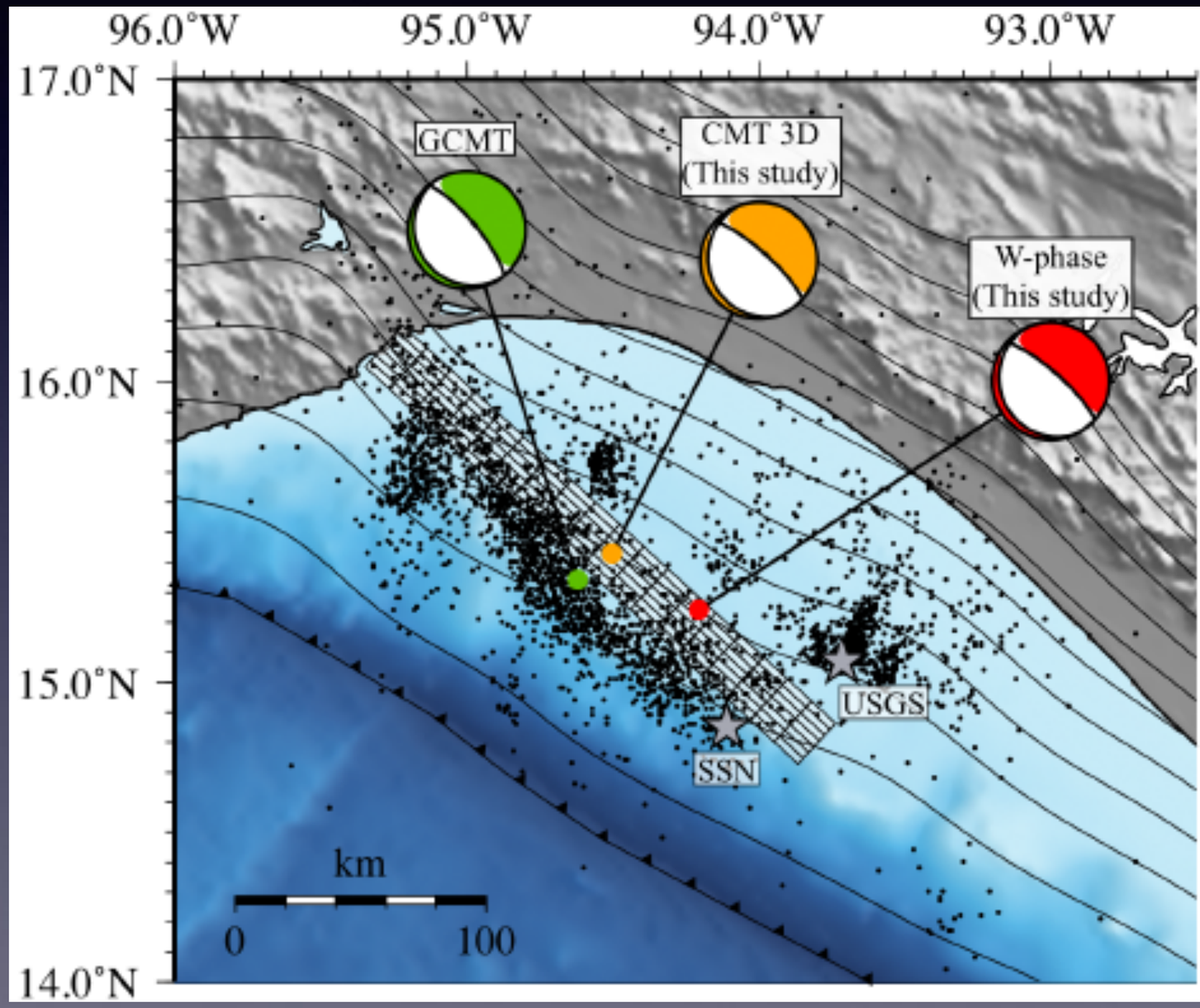
Southern Mexico 2017–2018



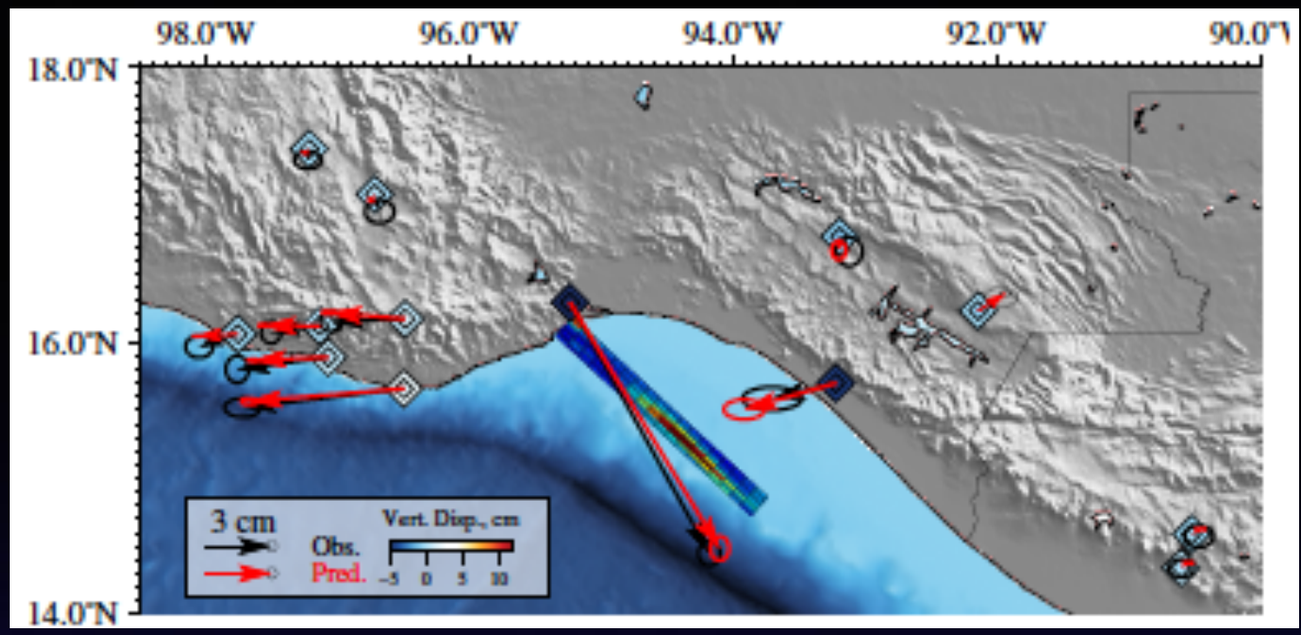
Mw8.2 Tehuantepec

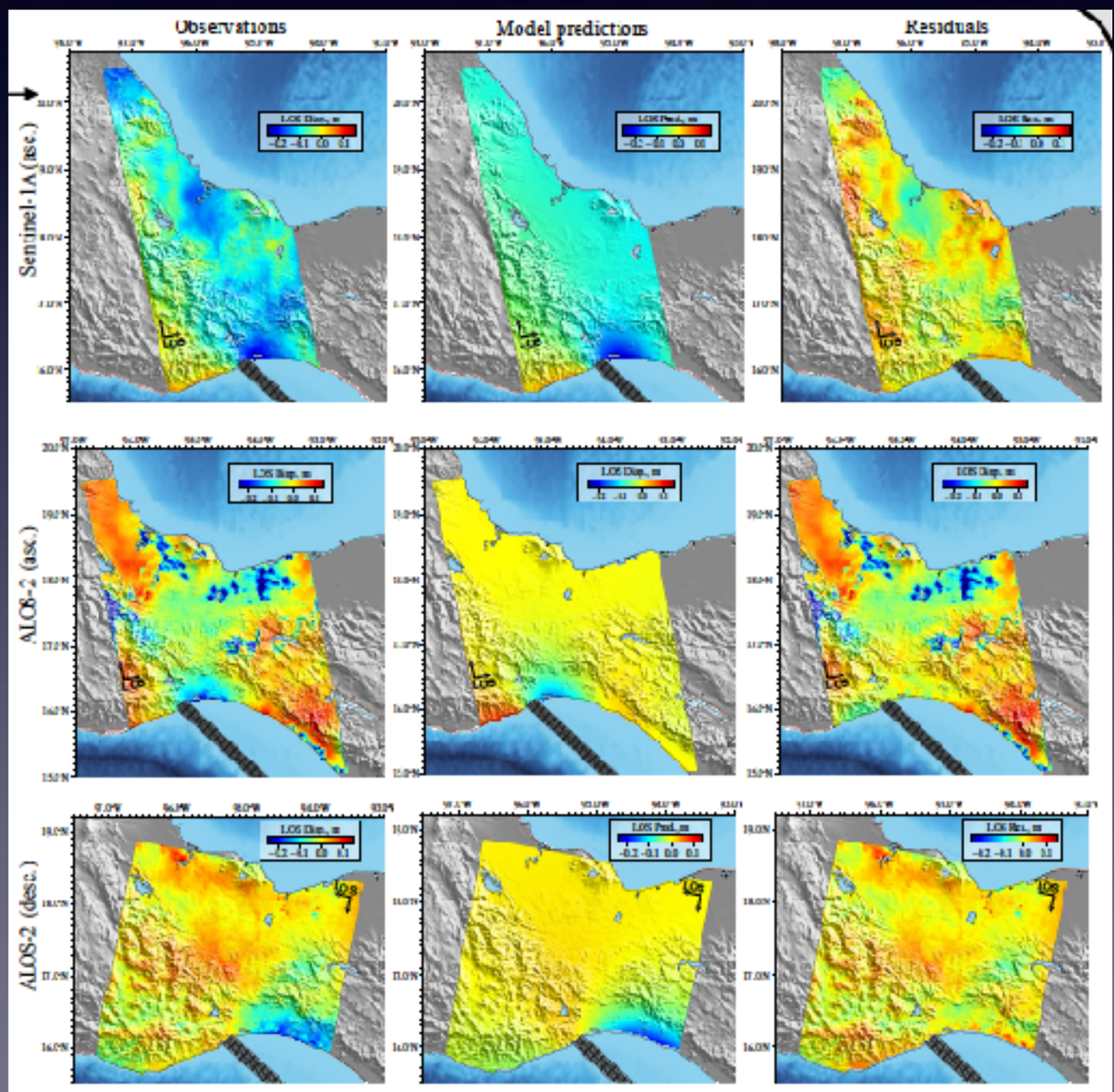
- 8 September 2017
- First large earthquake of sequence
- Rupture off-shore Chiapas and Oaxaca
- Hypocenter depth 58 km (SSN) 47.5 km (USGS)
- CMTs show normal slip on steeply dipping fault
- 3D CMT (Duputel) optimal centroid depth 40 km, time shift 24 sec
- W-phase (Duputel) optimal centroid depth 50 km



Bayesian static slip inversion

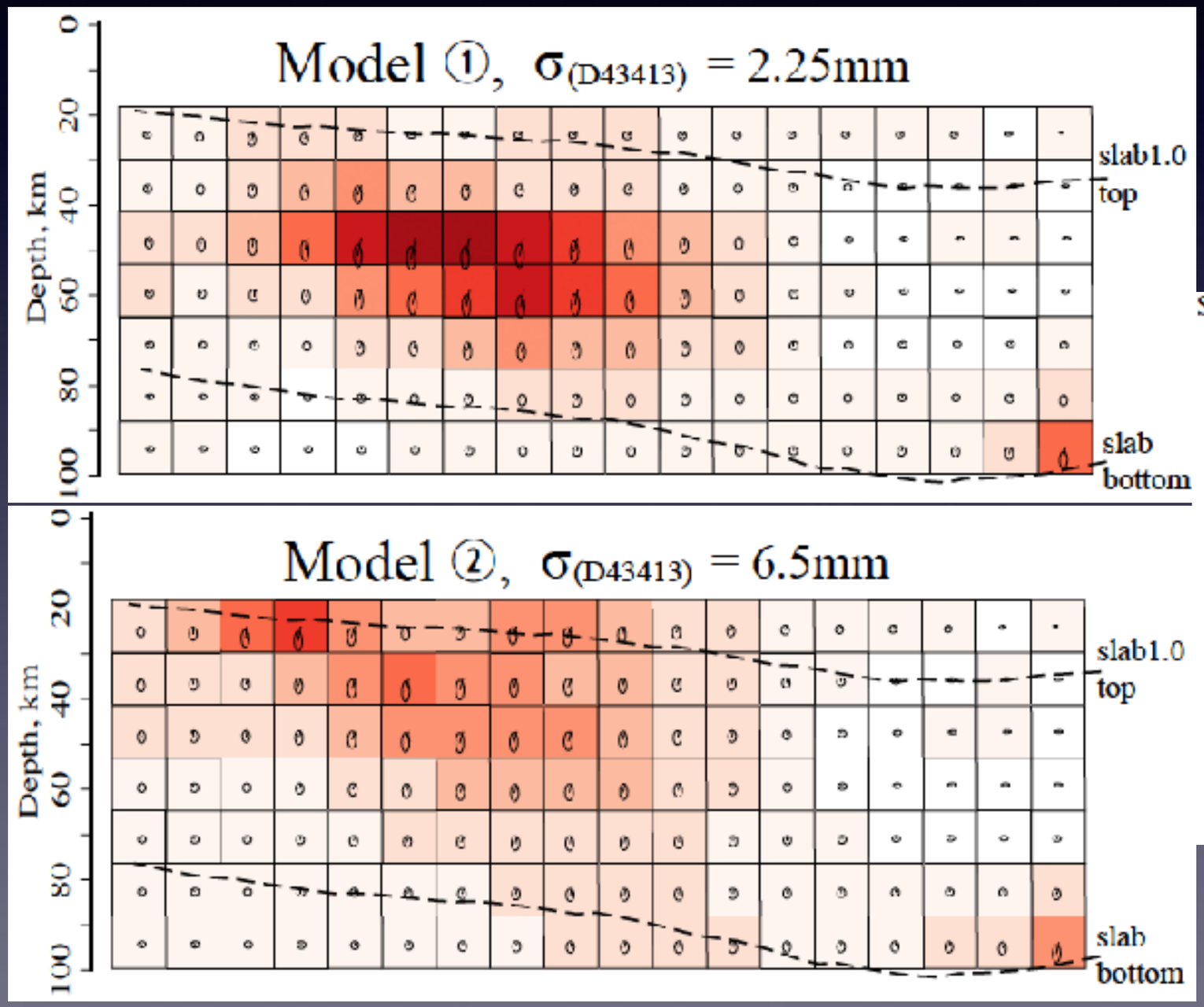
- Modeling Baptiste Gombert
- Grid search for optimum fault geometry strike 313°, dip 76°
- 72 by 216 km model fault, 12x12 km patches, Okada for Green's functions
- 2 Sentinel-1 interferograms (ascending and descending)
- ALOS-2 interferogram (desc.)
- 12 GPS displacements
- 3 DART buoy tsunami waveforms (Jiang)
- AlTar estimation of posterior PDFs for each fault patch (Minson et al., 2013)





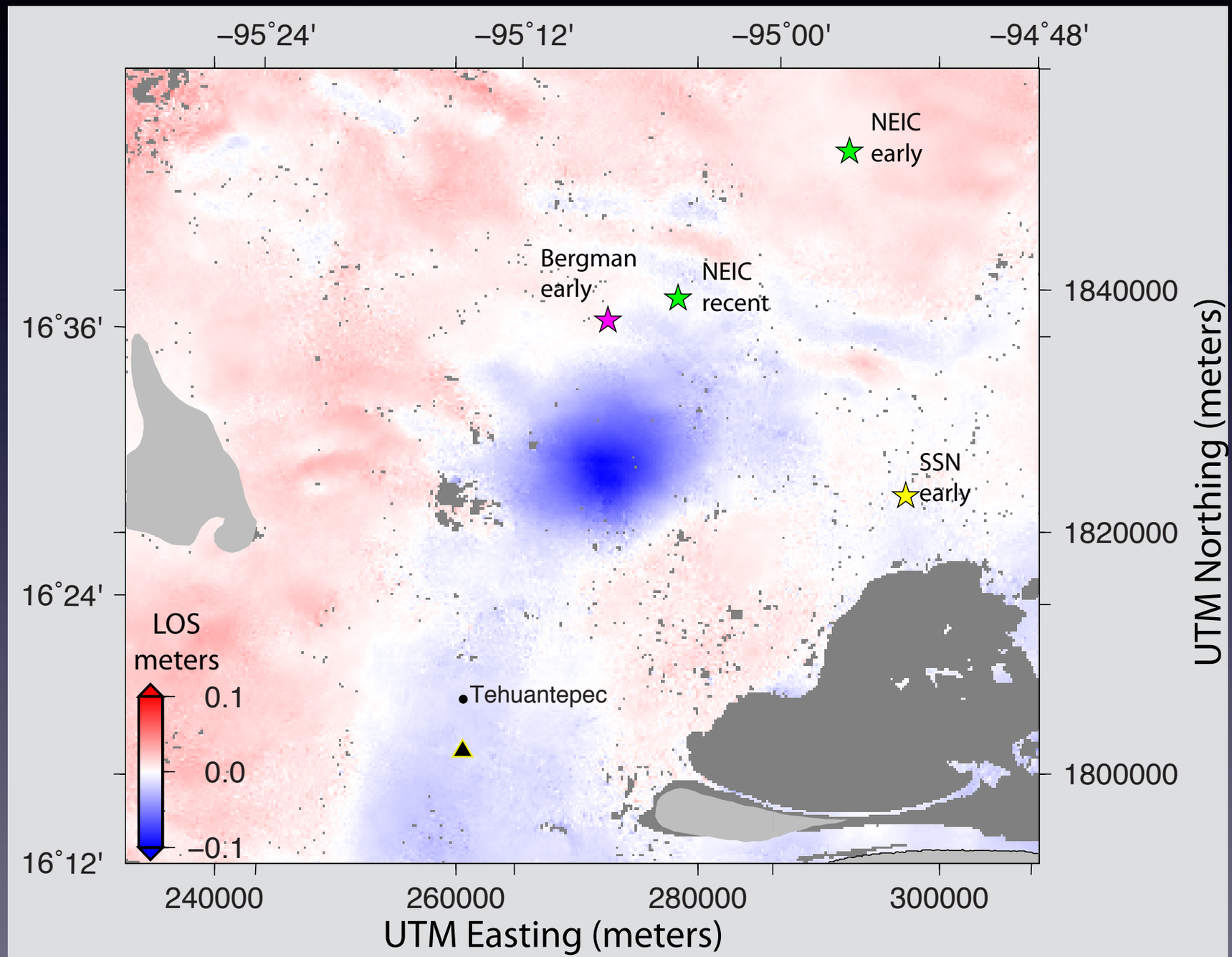
Tehuantepec static slip model

- AlTar Posterior mean slip
- No smoothing function
- Ellipses show 1-σ confidence from posterior PDF
- Slab top from Slab 1.0 (Hayes et al., 2012)
- Bottom assuming 50 km lithospheric thickness (Manea & Manea, 2008)
- Model 1 uses smaller *a priori* σ for DART station 43413
- Slip at NW end required to fit GPS and InSAR, could be very early postseismic



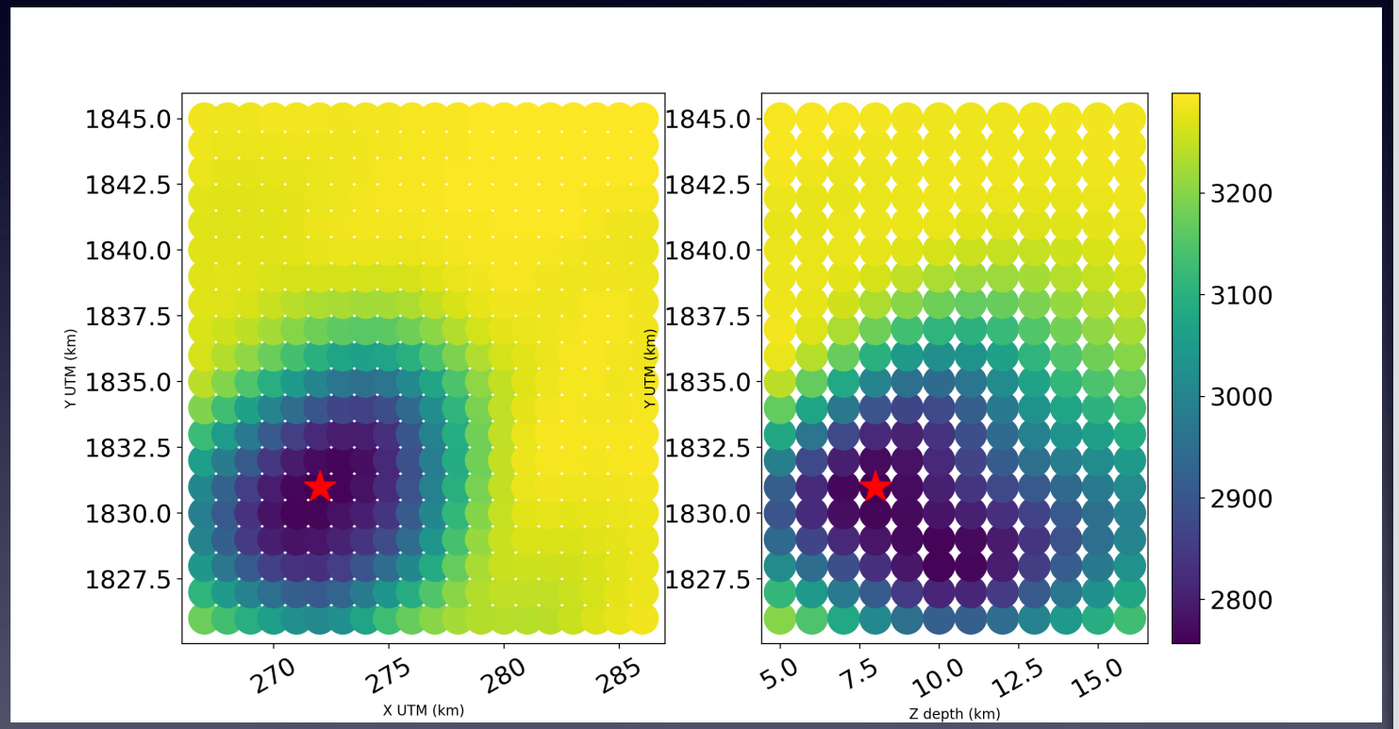
Mw 6.1 Ixtepec Earthquake

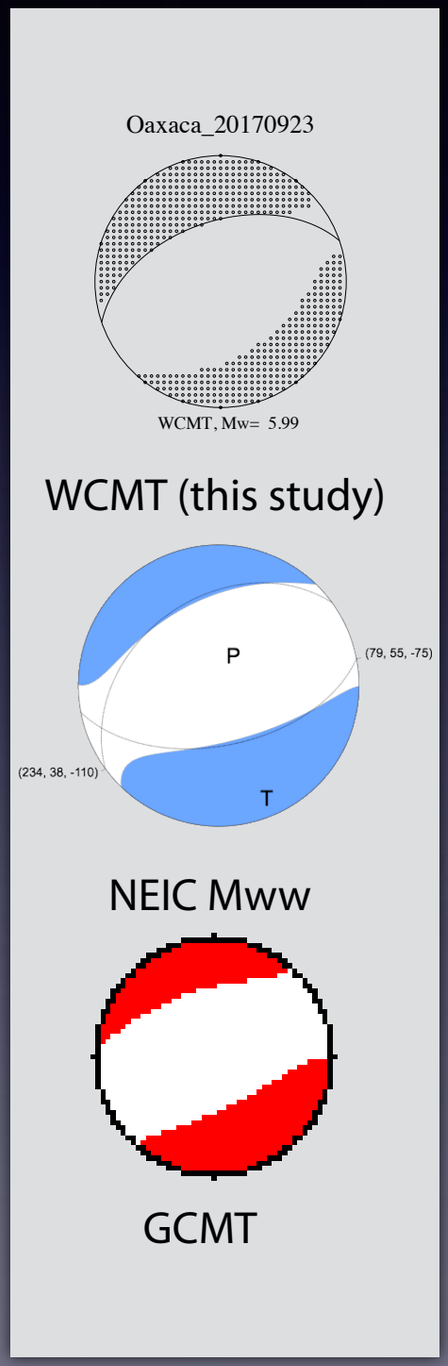
- 23 September 2017 near Ixtepec, Oaxaca
- Shallow normal-faulting event in upper plate crust
- Sentinel-1 InSAR descending track
- USGS NEIC early epicenter 30 km NE of InSAR signal, updated to about 10 km away
- SSN early epicenter 20 km east



Ixtepec fault geometry

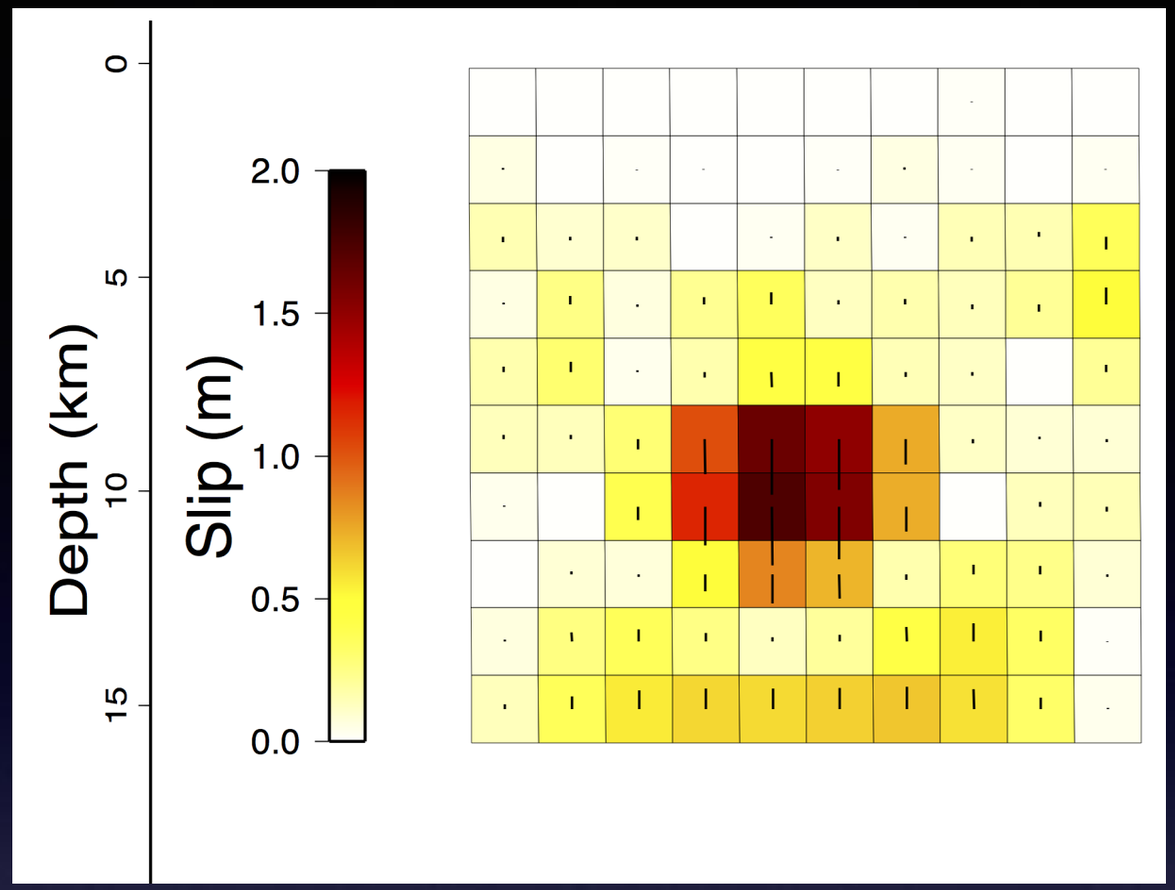
- InSAR not sensitive to strike and dip of fault
- Fixed strike 59° and dip 52° from GCMT
- Grid search for fault depth and location using Sentinel-1 Asc. & Desc., ALOS-2 Desc.
- Optimum depth of fault center 8 km, but could be as deep as 12 km



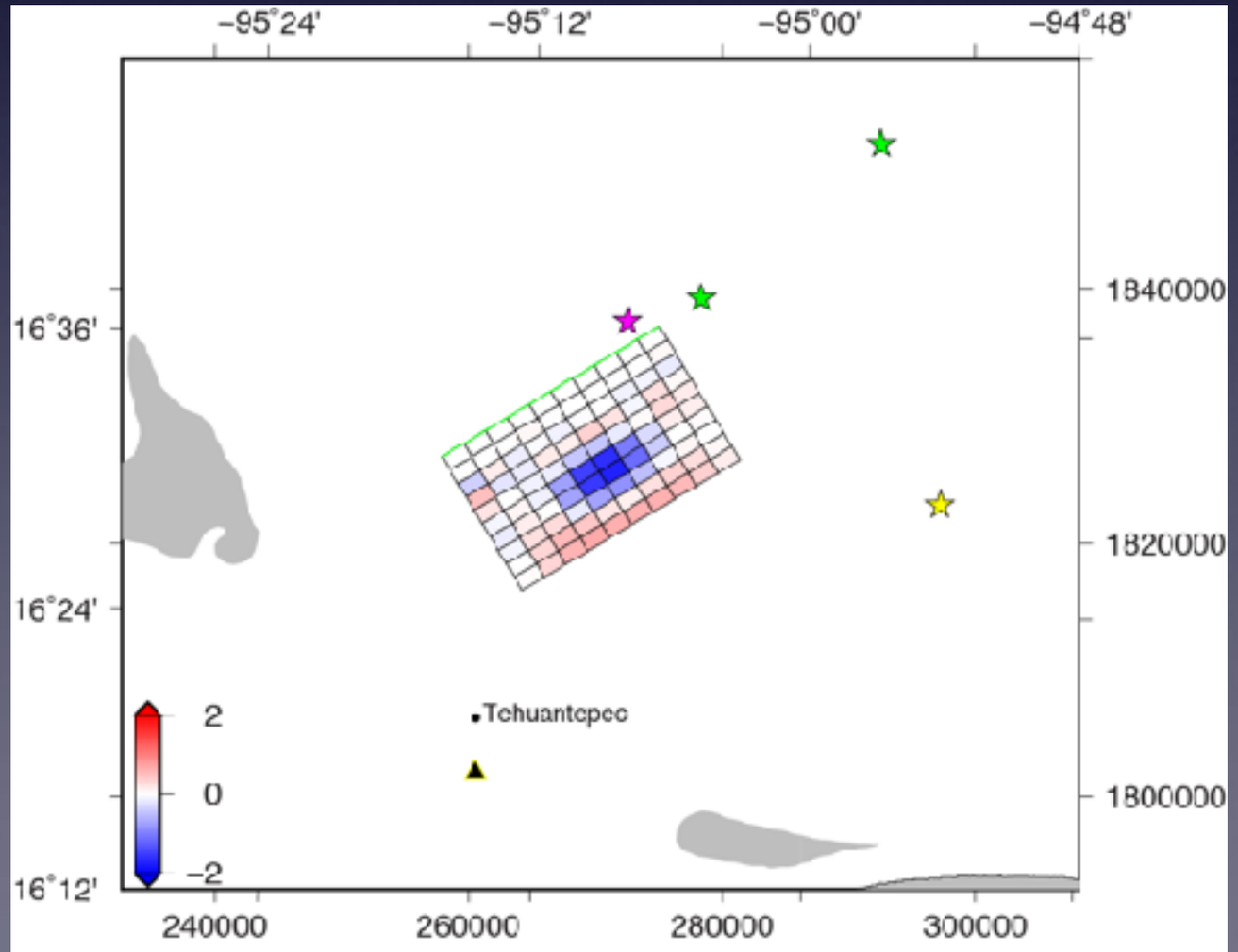


Ixtepec static slip

- Finite fault slip model with fixed fault geometry
- Classic Slip Inversion (CSI) package (Jolivet et al.)

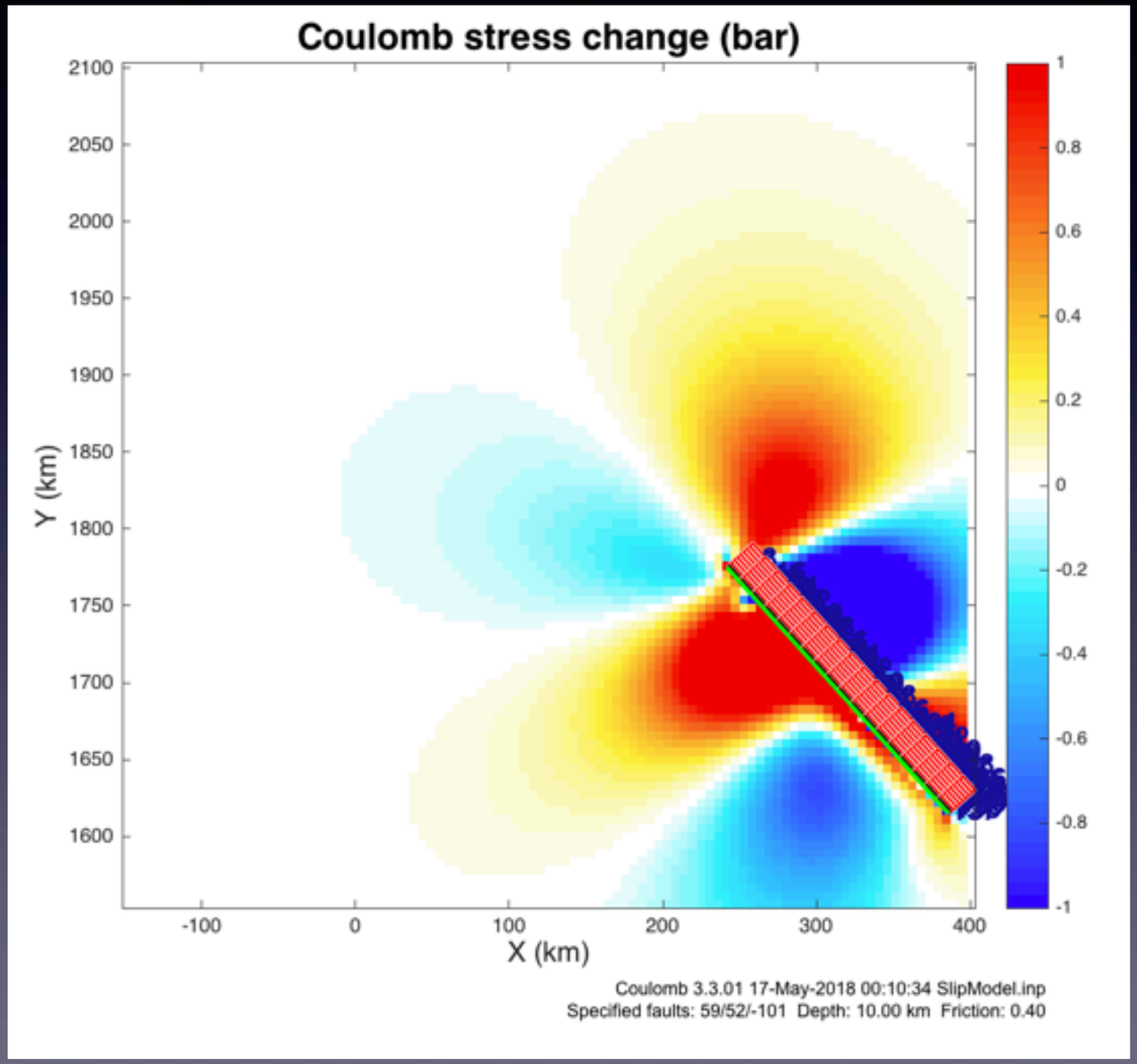


- 2 Sentinel-1 interferograms 1 ALOS-2 interferogram
- 2x2 km slip patches on 20 by 20 km model fault
- Only dip-slip allowed, no positivity constraint
- Very compact rupture between 8 and 12 km depth, 4–6 km length



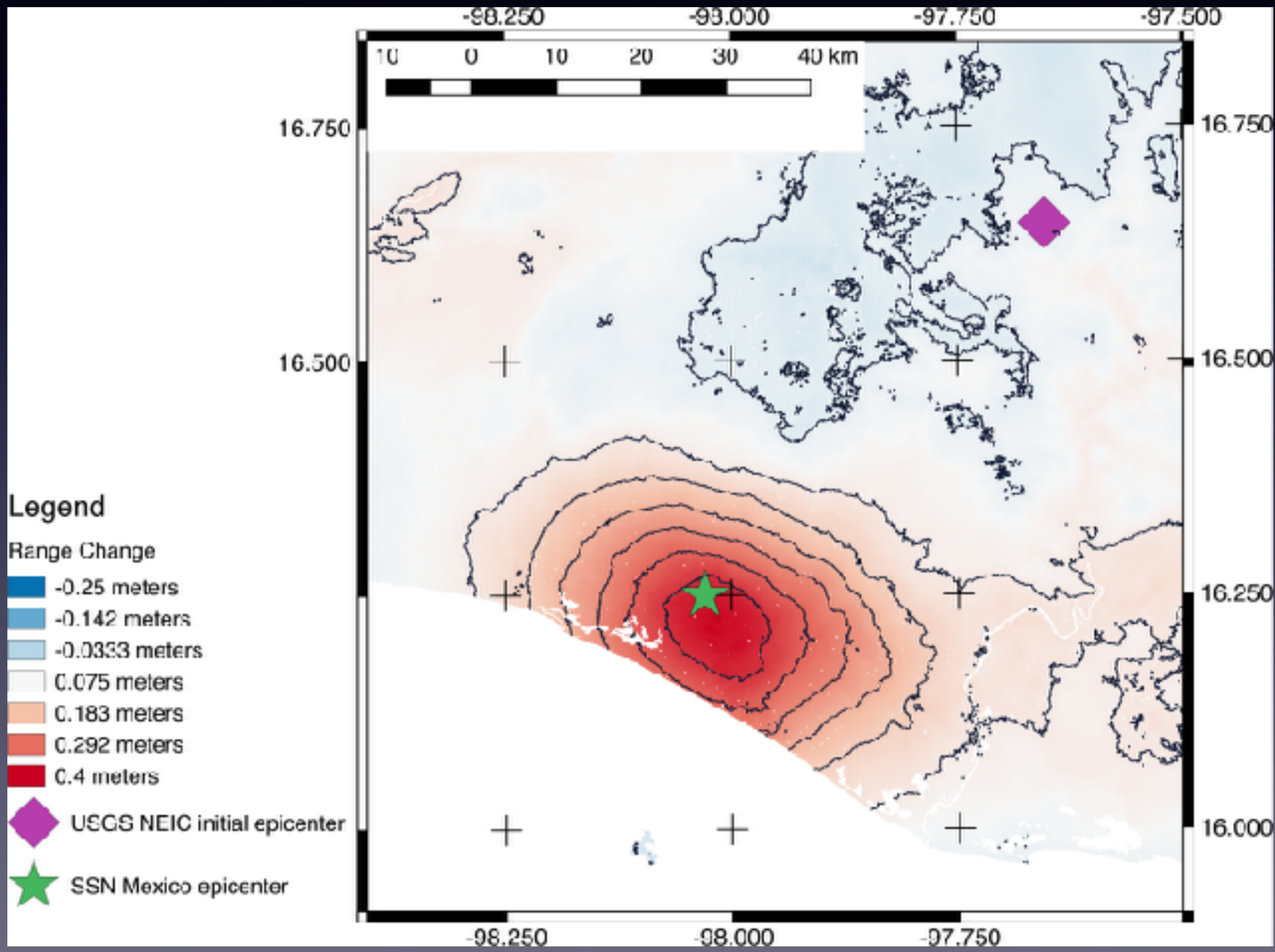
Coulomb stress change

- Coulomb stress change from Tehuantepec quake on faults strike/dip/rake 59°/52°/-101° like Ixtepec CMT
- Map at depth 10 km
- Increased Coulomb stress on normal faults over large area northwest of Tehuantepec earthquake
- ~1 bar Coulomb stress change on Ixtepec fault



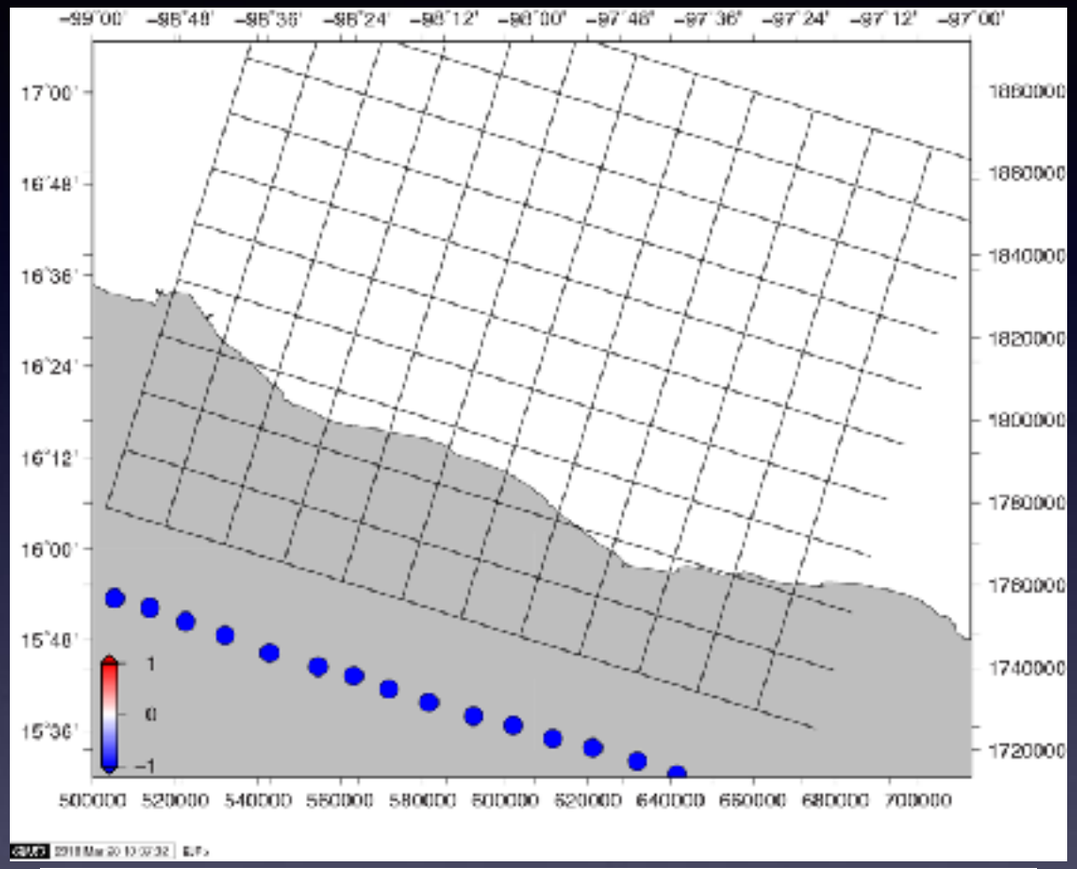
Mw 7.2 Pinotepa Earthquake

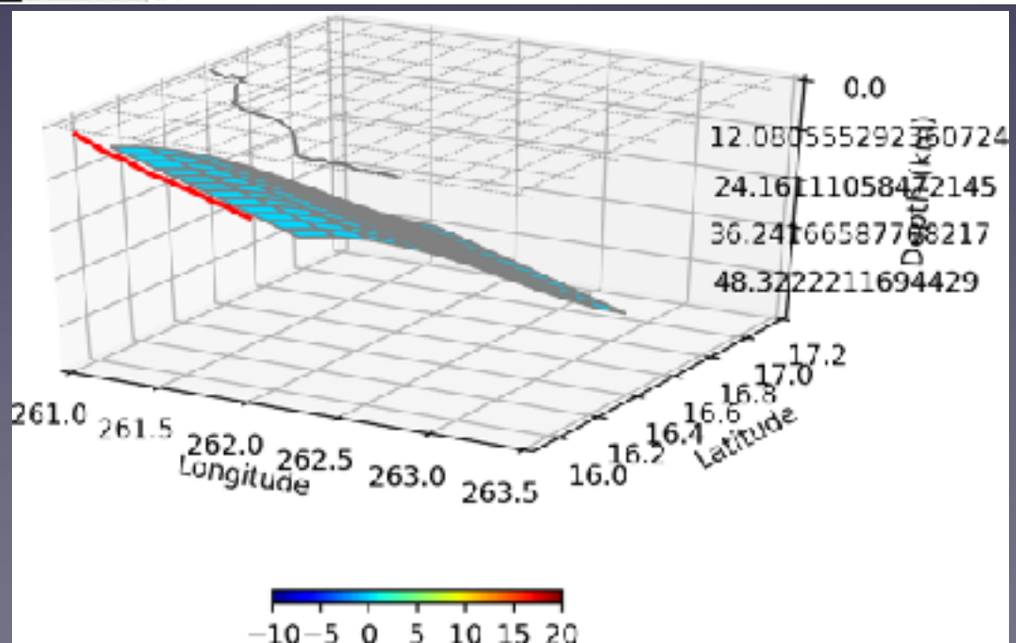
- Megathrust rupture 16 February 2018 near Pinotepa Nacional, Oaxaca
- Sentinel-1 SAR image acquired 1 hour after earthquake
- Interferogram automatically processed by ARIA data system ~12 hours after earthquake
- Initial USGS NEIC epicenter ~40 km to NW of InSAR
- Sent initial interferogram to USGS to inform hypocenter used in finite fault model and revised ShakeMap



Pinotepa static slip modeling

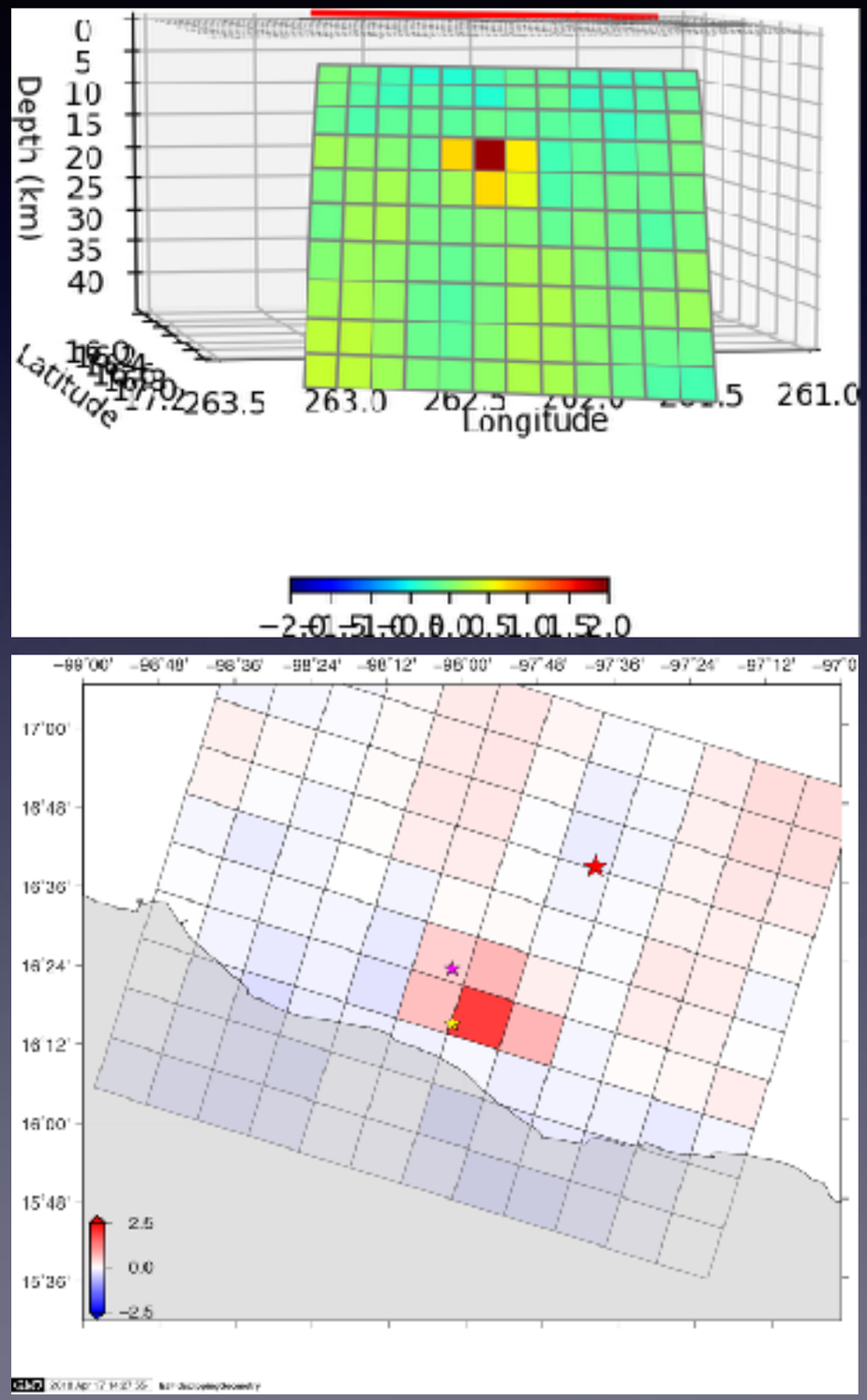
- Generated model fault from Slab1.0 database
- Includes down-dip curvature but not along-strike curvature
- Model fault v1: 20 km offset from trench, 160 km along-strike and 200 km down-dip
- 15x15 km patches





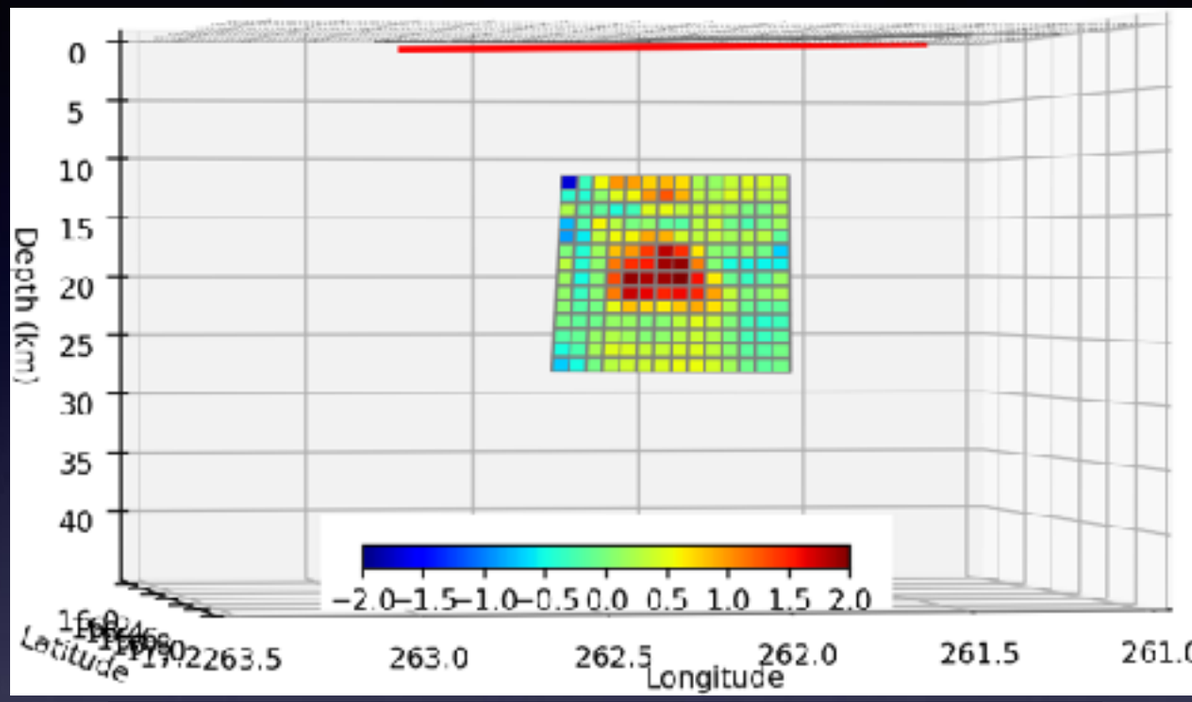
Pinotepa static slip modeling

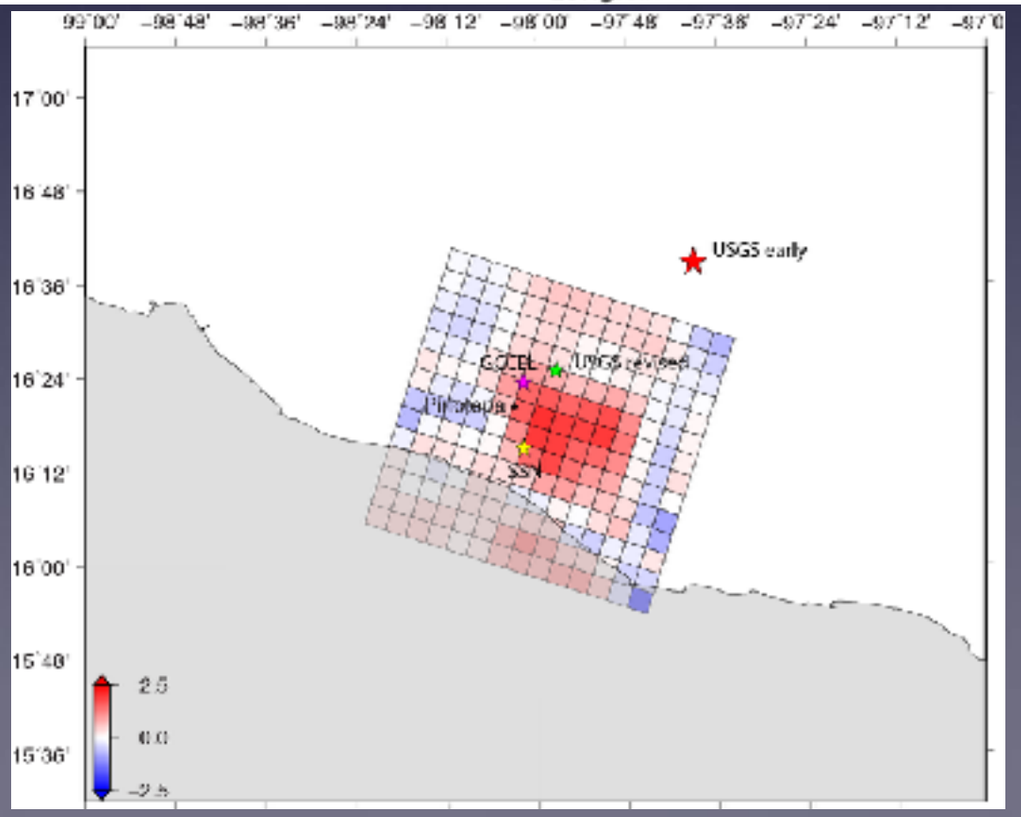
- Model fault v1 slip inversion with two Sentinel-1 interferograms (Desc. 143, Asc. 005)
- Dip-slip only, no positivity constraint
- Slip almost entirely in one 15x15 km patch near coast at 20–25 km depth
- USGS initial epicenter ~45 km NE (red star), SSN epicenter very close (yellow), GCCEL (Bergman et al.) relocation close (magenta star)



Pinotepa static slip modeling

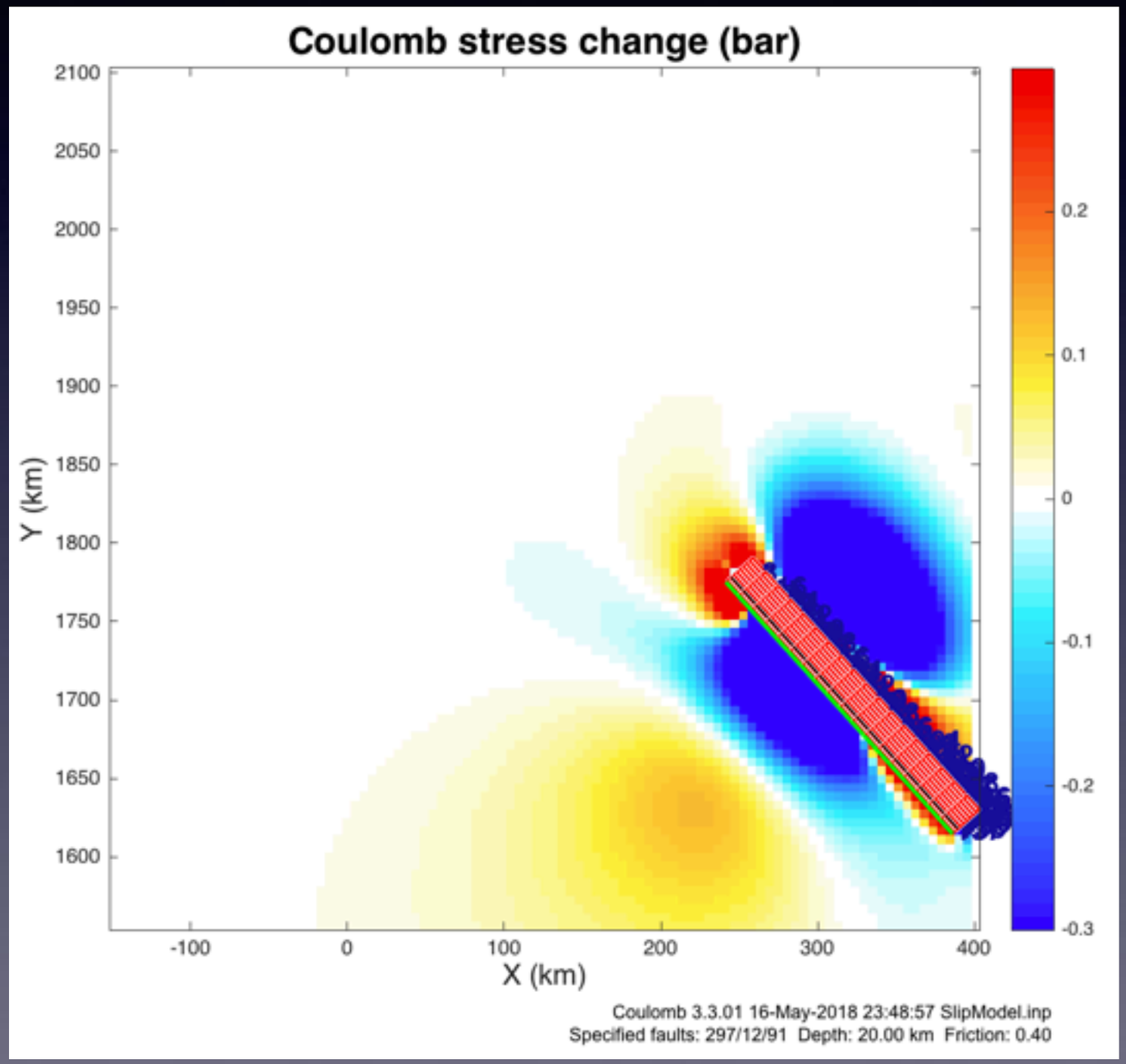
- Model fault v3 slip inversion with three Sentinel-1 ifgs (Desc. 143, Desc. 070, Asc. 005), ALOS-2 ifg (Desc. 150), GPS
- smaller model fault 70 x 70 km with 5x5 km patches
- Dip-slip only, no positivity constraint, smoothing function of Radiguet et al. (2012)
- Depth 17–22 km
- Slip about 10 by 20 km in this result, to be confirmed with full Bayesian inversion



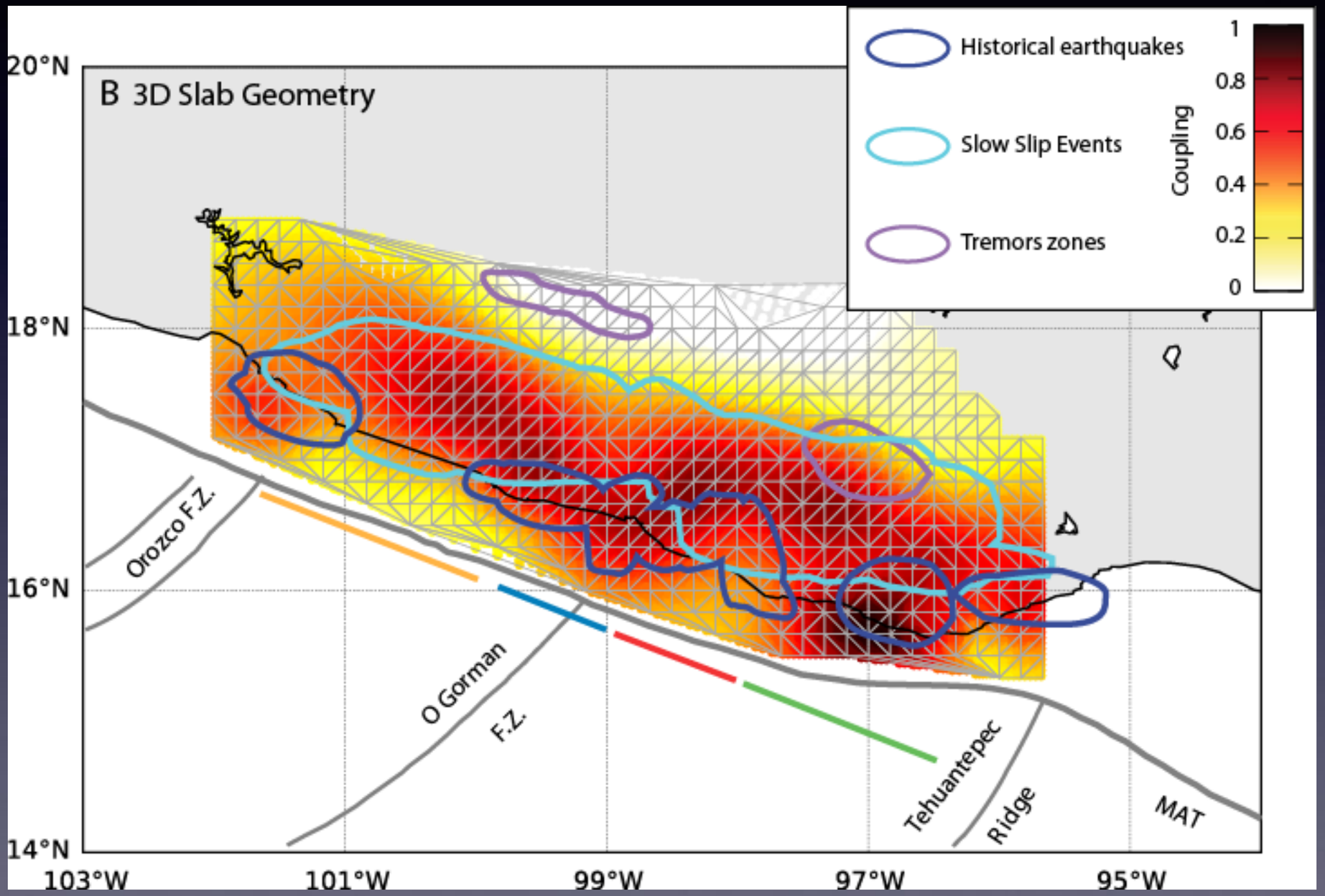


Coulomb stress change

- Coulomb stress change from Tehuantepec quake on thrust faults strike/dip/rake 297°/12°/91° like Pinotepa CMT
- Map at depth 20 km
- Increased Coulomb stress only very close to Tehuantepec earthquake
- No significant stress change at Pinotepa hypocenter

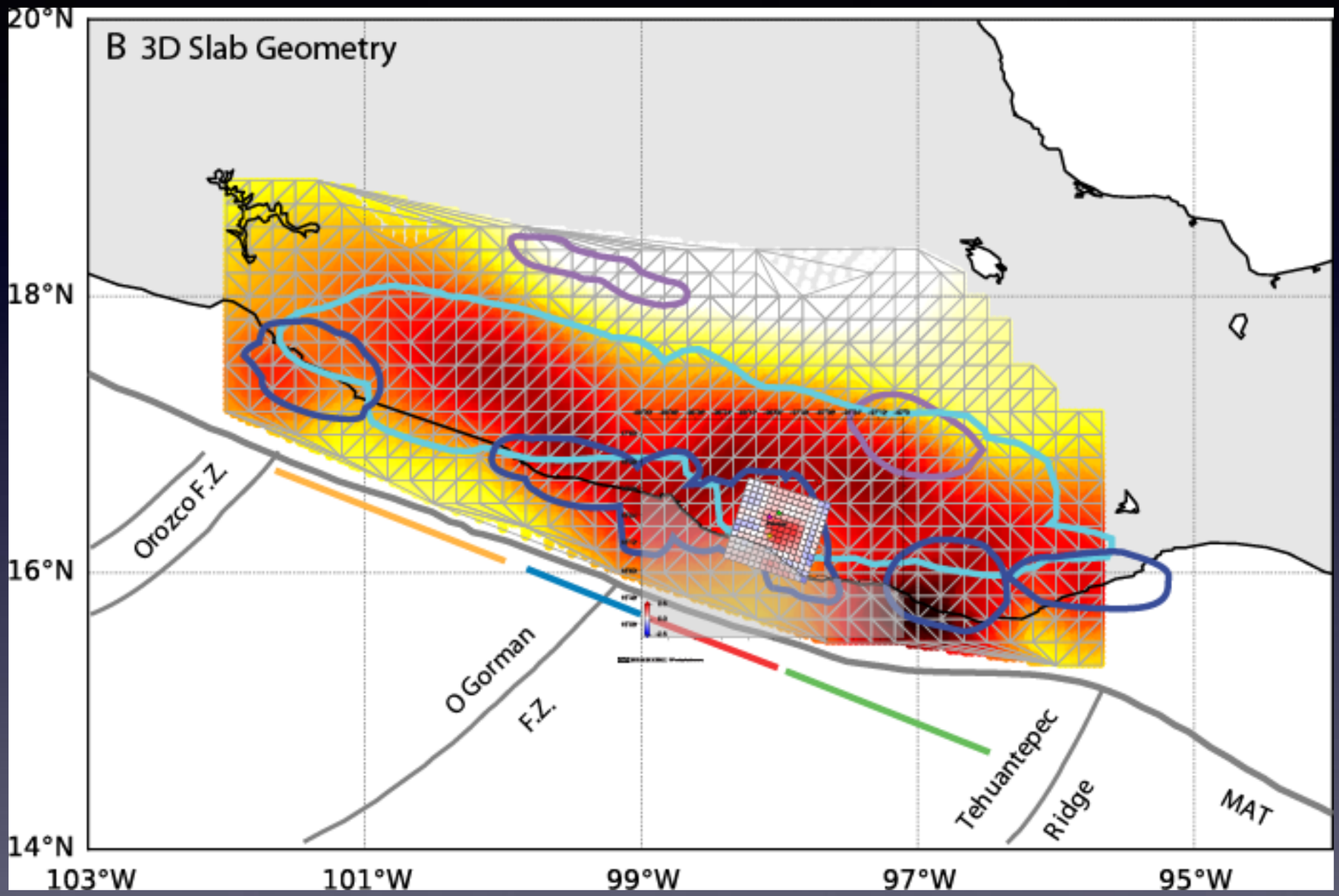


Oaxaca megathrust coupling



- Rousset et al. (2015) Pure Appl. Geoph. estimate from GPS

Oaxaca megathrust coupling



- 2018 M7.2 Pinotepa quake re-ruptured previous seismogenic area that overlaps with slow-slip event area

- 2018 slip just east of 2012 M7.1 earthquake slip Graham et al. (2014)

Conclusions

- M8.2 Tehuantepec 9/8 quake normal-fault rupture through most of subducting Cocos plate, at least 150 and maybe 220 km long

- M6.1 Ixtepec 9/23 quake in Oaxaca compact 4 x 6 km rupture at ~10 km depth in upper plate crust, likely aftershock of M8.2

- M7.2 Pinotepa 2/16 quake in Oaxaca on megathrust very compact 10x20 km at depth ~20 km in zone of many M7 quakes that may overlap SSEs